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## INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Article 36 and Rule 70)

Applicant's or agent's file reference <b>2003B133B</b>	FOR FURTHER ACTION      See Notification of Transmittal of International Preliminary Examination Report (Form PCT/IPEA/416)	
International application No. <b>PCT/US03/40341</b>	International filing date (day/month/year) <b>19 December 2003 (19.12.2003)</b>	Priority date (day/month/year) <b>20 December 2002 (20.12.2002)</b>
International Patent Classification (IPC) or national classification and IPC <b>IPC(7): C08F 236/02, 236/08 and US Cl.: 526/337,339</b>		
Applicant <b>EXXONMOBIL CHEMICAL PATENTS INC.</b>		

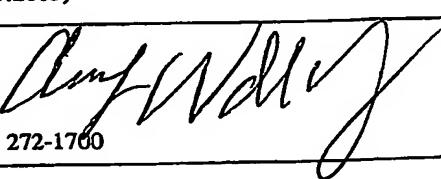
1. This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36.
2. This REPORT consists of a total of 3 sheets, including this cover sheet.

This report is also accompanied by ANNEXES, i.e., sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT).

These annexes consist of a total of 17 sheets.

3. This report contains indications relating to the following items:

- I  Basis of the report
- II  Priority
- III  Non-establishment of report with regard to novelty, inventive step and industrial applicability
- IV  Lack of unity of invention
- V  Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
- VI  Certain documents cited
- VII  Certain defects in the international application
- VIII  Certain observations on the international application

Date of submission of the demand <b>16 July 2004 (16.07.2004)</b>	Date of completion of this report <b>31 March 2005 (31.03.2005)</b>
Name and mailing address of the IPEA/US Mail Stop PCT, Attn: IPEA/ US Commissioner for Patents P.O. Box 1450 Alexandria, Virginia 22313-1450 Facsimile No. (703) 305-3230	Authorized officer <b>Roberto Rabago</b> Telephone No. (571) 272-1760 

## INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No.

PCT/US03/40341

**I. Basis of the report**

## 1. With regard to the elements of the international application:\*

 the international application as originally filed. the description:pages 1-104 as originally filedpages NONE, filed with the demandpages NONE, filed with the letter of \_\_\_\_\_. the claims:pages NONE, as originally filedpages NONE, as amended (together with any statement) under Article 19pages NONE, filed with the demandpages 105-121, filed with the letter of 30 November 2004 (30.11.2004) the drawings:pages 1-6, as originally filedpages NONE, filed with the demandpages NONE, filed with the letter of \_\_\_\_\_. the sequence listing part of the description:pages NONE, as originally filedpages NONE, filed with the demandpages NONE, filed with the letter of \_\_\_\_\_.

## 2. With regard to the language, all the elements marked above were available or furnished to this Authority in the language in which the international application was filed, unless otherwise indicated under this item.

These elements were available or furnished to this Authority in the following language \_\_\_\_\_ which is:

 the language of a translation furnished for the purposes of international search (under Rule 23.1(b)). the language of publication of the international application (under Rule 48.3(b)). the language of the translation furnished for the purposes of international preliminary examination (under Rules 55.2 and/or 55.3).

## 3. With regard to any nucleotide and/or amino acid sequence disclosed in the international application, the international preliminary examination was carried out on the basis of the sequence listing:

 contained in the international application in printed form. filed together with the international application in computer readable form. furnished subsequently to this Authority in written form. furnished subsequently to this Authority in computer readable form. The statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished. The statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished.4.  The amendments have resulted in the cancellation of: the description, pages NONE the claims, Nos. 71 the drawings, sheets/fig NONE5.  This report has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed, as indicated in the Supplemental Box (Rule 70.2(c)).\*\*

\* Replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to this report since they do not contain amendments (Rules 70.16 and 70.17).

\*\* Any replacement sheet containing such amendments must be referred to under item 1 and annexed to this report.

**INTERNATIONAL PRELIMINARY EXAMINATION REPORT**International application No.  
PCT/US03/40341**V. Reasoned statement under Rule 66.2(a)(ii) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement****1. STATEMENT**

Novelty (N)	Claims <u>1-70</u>	YES
	Claims <u>NONE</u>	NO
Inventive Step (IS)	Claims <u>1-70</u>	YES
	Claims <u>NONE</u>	NO
Industrial Applicability (IA)	Claims <u>1-70</u>	YES
	Claims <u>NONE</u>	NO

**2. CITATIONS AND EXPLANATIONS**

The following references as cited on the ISR are discussed:

D1: Priola et al. (US 4,107,417)

D2: Welch et al. (US 2,548,415)

D3: Calfee et al. (US 2,534,698)

Claims 1-70 meet the criteria set out in PCT Article 33(2)-(3), because the prior art does not teach or fairly suggest the claimed copolymer which has the required  $g'_{vis,avg}$ . Each of D1-D3 discloses polymers of isoolefins and multiolefins which appear to be "substantially free of long chain branching"; however, the reference disclosures contain no indication that the polymers described therein contain the claimed value of  $g'_{vis,avg}$ . Furthermore, the methods described in the specification for obtaining the claimed polymers are sufficiently different from those described in the cited references that no clear basis for concluding that the reference polymers inherently contain the claimed properties can be found.

Claims 1-70 meet the criteria set out in PCT Article 33(4), and thus have industrial applicability because the subject matter claimed can be made or used in industry.

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 NEW CITATIONS 

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## CLAIMS

What is claimed is:

1. A copolymer comprising an isoolefin and a multiolefin, the copolymer being substantially free of long chain branching; wherein the copolymer has a g'<sub>vis,avg.</sub> from greater than or equal to 0.978 as determined by triple detection SEC.
2. The copolymer of claim 1, wherein the multiolefin is a conjugated diene, preferably isoprene.
3. The copolymer of claim 1, wherein the multiolefin content is from greater than 0.5 mol%.
4. The copolymer of claim 1, wherein the multiolefin content is from greater than 1.0 mol%.
5. The copolymer of claim 1, wherein the multiolefin content is from greater than 2.5 mol%.
6. The copolymer of claim 1, wherein the multiolefin content is from greater than 5.0 mol%.
7. A copolymer comprising isobutylene and isoprene, the copolymer being substantially free of long chain branching; wherein the copolymer has a g'<sub>vis,avg.</sub> from greater than or equal to 0.978 as determined by triple detection SEC.
8. The copolymer of claim 7, wherein the isoprene content is from greater than 0.5 mol%.

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9. The copolymer of claim 7, wherein the isoprene content is from greater than 1.0 mol%.
  10. The copolymer of claim 7, wherein the isoprene content is from greater than 2.5 mol%.
  11. The copolymer of claim 7, wherein the isoprene content is from greater than 5.0 mol%.
  12. A copolymer produced by the process comprising contacting an isoolefin, preferably isobutylene, a multiolefin, preferably isoprene, one or more Lewis acid(s), one or more initiator(s), and a diluent comprising one or more hydrofluorocarbon(s) (HFC's); wherein the copolymer is substantially free of long chain branching and wherein the copolymer has a  $g'_{vis,avg}$  from greater than or equal to 0.978 as determined by triple detection SEC.
  13. The copolymer of claim 12, wherein the multiolefin is a conjugated diene.
  14. The copolymer of claim 12, wherein the multiolefin content is from greater than 0.5 mol%.
  15. The copolymer of claim 12, wherein the multiolefin content is from greater than 1.0 mol%.
  16. The copolymer of claim 12, wherein the multiolefin content is from greater than 2.5 mol%.
  17. The copolymer of claim 12, wherein the multiolefin content is from greater than 5.0 mol%.

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18. The copolymer of claim 12, wherein one or more hydrofluorocarbon(s) is represented by the formula:  $C_xH_yF_z$  wherein x is an integer from 1 to 40 and y and z are integers of one or more.
19. The copolymer of claim 18, wherein x is from 1 to 10.
20. The copolymer of claim 18, wherein x is from 1 to 6.
21. The copolymer of claim 18, wherein x is from 1 to 3.
22. The copolymer of claim 12, wherein the one or more hydrofluorocarbon(s) is independently selected from the group consisting of fluoromethane; difluoromethane; trifluoromethane; fluoroethane; 1,1-difluoroethane; 1,2-difluoroethane; 1,1,1-trifluoroethane; 1,1,2-trifluoroethane; 1,1,1,2-tetrafluoroethane; 1,1,2,2-tetrafluoroethane; 1,1,1,2,2-pentafluoroethane; 1-fluoropropane; 2-fluoropropane; 1,1-difluoropropane; 1,2-difluoropropane; 1,3-difluoropropane; 2,2-difluoropropane; 1,1,1-trifluoropropane; 1,1,2-trifluoropropane; 1,1,3-trifluoropropane; 1,2,2-trifluoropropane; 1,2,3-trifluoropropane; 1,1,1,2-tetrafluoropropane; 1,1,1,3-tetrafluoropropane; 1,1,2,2-tetrafluoropropane; 1,1,2,3-tetrafluoropropane; 1,1,3,3-tetrafluoropropane; 1,2,2,3-tetrafluoropropane; 1,1,1,2,2-pentafluoropropane; 1,1,1,2,3-pentafluoropropane; 1,1,1,3,3-pentafluoropropane; 1,1,2,2,3-pentafluoropropane; 1,1,1,2,2,3-hexafluoropropane; 1,1,1,2,3,3-hexafluoropropane; 1,1,1,2,2,3-heptafluoropropane; 1,1,1,2,3,3,3-heptafluoropropane; 1-fluorobutane; 2-fluorobutane; 1,1-difluorobutane; 1,2-difluorobutane; 1,3-difluorobutane; 1,4-difluorobutane; 2,2-difluorobutane; 2,3-difluorobutane; 1,1,1-trifluorobutane; 1,1,2-trifluorobutane; 1,1,3-trifluorobutane; 1,1,4-trifluorobutane; 1,2,2-trifluorobutane; 1,2,3-trifluorobutane; 1,3,3-trifluorobutane; 2,2,3-trifluorobutane; 1,1,1,2-tetrafluorobutane; 1,1,1,3-tetrafluorobutane; 1,1,1,4-tetrafluorobutane; 1,1,2,2-tetrafluorobutane;

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1,1,2,3-tetrafluorobutane;	1,1,2,4-tetrafluorobutane;	1,1,3,3-tetrafluorobutane;
1,1,3,4-tetrafluorobutane;	1,1,4,4-tetrafluorobutane;	1,2,2,3-tetrafluorobutane;
1,2,2,3-tetrafluorobutane;	1,2,2,4-tetrafluorobutane;	1,2,3,3-tetrafluorobutane;
1,2,3,4-tetrafluorobutane;	2,2,3,3-tetrafluorobutane;	1,1,1,2,2-pentafluorobutane;
1,1,1,2,2-pentafluorobutane;	1,1,1,2,3-pentafluorobutane;	1,1,1,2,4-pentafluorobutane;
1,1,1,3,3-pentafluorobutane;	1,1,1,4,4-pentafluorobutane;	1,1,1,3,4-pentafluorobutane;
1,1,1,4,4-pentafluorobutane;	1,1,2,2,4-pentafluorobutane;	1,1,2,2,3-pentafluorobutane;
1,1,2,2,4-pentafluorobutane;	1,1,2,4,4-pentafluorobutane;	1,1,2,3,3-pentafluorobutane;
1,1,2,4,4-pentafluorobutane;	1,2,2,3,3-pentafluorobutane;	1,1,3,3,4-pentafluorobutane;
1,2,2,3,3-pentafluorobutane;	1,1,1,2,2,3-hexafluorobutane;	1,2,2,3,4-pentafluorobutane;
1,1,1,2,2,3-hexafluorobutane;	1,1,1,2,3,3-hexafluorobutane;	1,1,1,2,2,4-hexafluorobutane;
1,1,1,2,3,3-hexafluorobutane;	1,1,1,2,4,4-hexafluorobutane;	1,1,1,2,3,4-hexafluorobutane;
1,1,1,2,4,4-hexafluorobutane;	1,1,1,3,4,4-hexafluorobutane;	1,1,1,3,4,4-hexafluorobutane;
1,1,1,3,4,4-hexafluorobutane;	1,1,2,2,3,3-hexafluorobutane;	1,1,2,2,3,4-hexafluorobutane;
1,1,2,2,3,3-hexafluorobutane;	1,1,2,2,4,4-hexafluorobutane;	1,1,2,3,3,4-hexafluorobutane;
1,1,2,2,4,4-hexafluorobutane;	1,1,2,3,4,4-hexafluorobutane;	1,1,2,3,4,4-hexafluorobutane;
1,1,2,3,4,4-hexafluorobutane;	1,1,1,2,2,3,3-heptafluorobutane;	1,1,1,2,2,4,4-heptafluorobutane;
1,1,1,2,2,3,3-heptafluorobutane;	1,1,1,2,2,3,4-heptafluorobutane;	1,1,1,2,3,3,4-heptafluorobutane;
1,1,1,2,2,3,4-heptafluorobutane;	1,1,1,2,3,4,4-heptafluorobutane;	1,1,1,2,4,4,4-heptafluorobutane;
1,1,1,2,3,4,4-heptafluorobutane;	1,1,1,3,3,4,4-heptafluorobutane;	1,1,1,2,2,3,3,4-heptafluorobutane;
1,1,1,3,3,4,4-heptafluorobutane;	1,1,1,2,2,3,4,4-octafluorobutane;	1,1,1,2,3,3,4,4-octafluorobutane;
1,1,1,2,2,3,4,4-octafluorobutane;	1,1,1,2,2,4,4,4-octafluorobutane;	1,1,1,2,3,4,4,4-octafluorobutane;
1,1,1,2,2,4,4,4-octafluorobutane;	1,1,1,2,2,3,3,4,4-nonafluorobutane;	1,1,1,2,2,3,4,4,4-nonafluorobutane;
1,1,1,2,2,3,3,4,4-nonafluorobutane;	1-fluoro-2-methylpropane;	1,1-difluoro-2-methylpropane;
1-fluoro-2-methylpropane;	1,3-difluoro-2-methylpropane;	1,1,1-trifluoro-2-methylpropane;
1,3-difluoro-2-methylpropane;	1,1,1-trifluoro-2-(fluoromethyl)propane;	1,3-difluoro-2-(fluoromethyl)propane;
1,1,1-trifluoro-2-(fluoromethyl)propane;	1,1,1,3,3-pentafluoro-2-methylpropane;	1,1,1,3,3-tetrafluoro-2-(fluoromethyl)propane;
1,1,1,3,3-pentafluoro-2-methylpropane;	1,1,1,3-tetrafluoro-2-(fluoromethyl)propane;	1,1,1,3-tetrafluoro-2-(fluoromethyl)propane;
1,1,1,3-tetrafluoro-2-(fluoromethyl)propane;	fluorocyclobutane;	1,1-difluorocyclobutane;
fluorocyclobutane;	1,1-difluorocyclobutane;	1,2-difluorocyclobutane;
1,1-difluorocyclobutane;	1,2-difluorocyclobutane;	1,3-difluorocyclobutane;

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difluorocyclobutane;	1,1,2-trifluorocyclobutane;	1,1,3-
trifluorocyclobutane;	1,2,3-trifluorocyclobutane;	1,1,2,2-
tetrafluorocyclobutane;	1,1,3,3-tetrafluorocyclobutane;	1,1,2,2,3-
pentafluorocyclobutane;	1,1,2,3,3-pentafluorocyclobutane;	1,1,2,2,3,3-
hexafluorocyclobutane;	1,1,2,2,3,4-hexafluorocyclobutane;	1,1,2,3,3,4-
hexafluorocyclobutane;	1,1,2,2,3,4-heptafluorocyclobutane;	vinyli-
fluoride;	1,1-difluoroethene; 1,2-difluoroethene; 1,1,2-trifluoroethene;	1-
fluoropropene,	1,1-difluoropropene; 1,2-difluoropropene;	1,3-
disfluoropropene;	2,3-difluoropropene; 3,3-difluoropropene;	1,1,2-
trifluoropropene;	1,1,3-trifluoropropene; 1,2,3-trifluoropropene;	1,3,3-
trifluoropropene;	2,3,3-trifluoropropene; 3,3,3-trifluoropropene; 1-fluoro-	
1-butene;	2-fluoro-1-butene; 3-fluoro-1-butene; 4-fluoro-1-butene;	1,1-
difluoro-1-butene;	1,2-difluoro-1-butene; 1,3-difluoropropene;	1,4-
difluoro-1-butene;	2,3-difluoro-1-butene; 2,4-difluoro-1-butene;	3,3-
difluoro-1-butene;	3,4-difluoro-1-butene; 4,4-difluoro-1-butene;	1,1,2-
trifluoro-1-butene;	1,1,3-trifluoro-1-butene; 1,1,4-trifluoro-1-butene;	1,2,3-
trifluoro-1-butene;	1,2,4-trifluoro-1-butene; 1,3,3-trifluoro-1-butene;	1,3,4-
trifluoro-1-butene;	1,4,4-trifluoro-1-butene; 2,3,3-trifluoro-1-butene;	2,3,4-
trifluoro-1-butene;	2,4,4-trifluoro-1-butene; 3,3,4-trifluoro-1-butene;	3,4,4-
trifluoro-1-butene;	4,4,4-trifluoro-1-butene; 1,1,2,3-tetrafluoro-1-butene;	
1,1,2,4-tetrafluoro-1-butene;	1,1,3,3-tetrafluoro-1-butene;	1,1,3,4-
tetrafluoro-1-butene;	1,1,4,4-tetrafluoro-1-butene; 1,2,3,3-tetrafluoro-1-	
butene;	1,2,3,4-tetrafluoro-1-butene; 1,2,4,4-tetrafluoro-1-butene;	1,3,3,4-
tetrafluoro-1-butene;	1,3,4,4-tetrafluoro-1-butene; 1,4,4,4-tetrafluoro-1-	
butene;	2,3,3,4-tetrafluoro-1-butene; 2,3,4,4-tetrafluoro-1-butene;	2,4,4,4-
tetrafluoro-1-butene;	3,3,4,4-tetrafluoro-1-butene; 3,4,4,4-tetrafluoro-1-	
butene;	1,1,2,3,3-pentafluoro-1-butene; 1,1,2,3,4-pentafluoro-1-butene;	
1,1,2,4,4-pentafluoro-1-butene;	1,1,3,3,4-pentafluoro-1-butene;	1,1,3,4,4-
pentafluoro-1-butene;	1,1,4,4,4-pentafluoro-1-butene;	1,2,3,3,4-
pentafluoro-1-butene;	1,2,3,4,4-pentafluoro-1-butene;	1,2,4,4,4-
pentafluoro-1-butene;	2,3,3,4,4-pentafluoro-1-butene;	2,3,4,4,4-
pentafluoro-1-butene;	3,3,4,4,4-pentafluoro-1-butene;	1,1,2,3,3,4-

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hexafluoro-1-butene; 1,1,2,3,4,4-hexafluoro-1-butene; 1,1,2,4,4,4-hexafluoro-1-butene; 1,2,3,3,4,4-hexafluoro-1-butene; 1,2,3,4,4,4-hexafluoro-1-butene; 2,3,3,4,4,4-hexafluoro-1-butene; 1,1,2,3,3,4,4-heptafluoro-1-butene; 1,1,3,3,4,4,4-heptafluoro-1-butene; 1,2,3,3,4,4-heptafluoro-1-butene; 1-fluoro-2-butene; 2-fluoro-2-butene; 1,1-difluoro-2-butene; 1,2-difluoro-2-butene; 1,3-difluoro-2-butene; 1,4-difluoro-2-butene; 2,3-difluoro-2-butene; 1,1,1-trifluoro-2-butene; 1,1,2-trifluoro-2-butene; 1,1,3-trifluoro-2-butene; 1,1,4-trifluoro-2-butene; 1,2,3-trifluoro-2-butene; 1,2,4-trifluoro-2-butene; 1,1,1,2-tetrafluoro-2-butene; 1,1,1,3-tetrafluoro-2-butene; 1,1,1,4-tetrafluoro-2-butene; 1,1,2,3-tetrafluoro-2-butene; 1,1,2,4-tetrafluoro-2-butene; 1,2,3,4-tetrafluoro-2-butene; 1,1,1,2,3-pentafluoro-2-butene; 1,1,1,2,4-pentafluoro-2-butene; 1,1,1,3,4-pentafluoro-2-butene; 1,1,1,4,4-pentafluoro-2-butene; 1,1,2,3,4-pentafluoro-2-butene; 1,1,1,2,3,4-hexafluoro-2-butene; 1,1,1,3,4,4-hexafluoro-2-butene; 1,1,1,2,3,4,4-hexafluoro-2-butene; 1,1,1,2,4,4-heptafluoro-2-butene; and mixtures thereof.

23. The copolymer of claim 12, wherein the one or more hydrofluorocarbon(s) is independently selected from the group consisting of fluoromethane, difluoromethane, trifluoromethane, 1,1-difluoroethane, 1,1,1-trifluoroethane, 1,1,1,2-tetrafluoroethane, and mixtures thereof.
24. The copolymer of claim 12, wherein the diluent comprises from 15 to 100 volume % HFC based upon the total volume of the diluent.
25. The copolymer of claim 12, wherein the diluent comprises from 20 to 100 volume % HFC based upon the total volume of the diluent.

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26. The copolymer of claim 12, wherein the diluent comprises from 25 to 100 volume % HFC based upon the total volume of the diluent.
27. The copolymer of claim 12, wherein the diluent further comprises a hydrocarbon, a non-reactive olefin, and/or an inert gas.
28. The copolymer of claim 27, wherein the hydrocarbon is a halogenated hydrocarbon other than an HFC.
29. The copolymer of claim 28, wherein the halogenated hydrocarbon is methyl chloride.
30. The copolymer of claim 12, wherein the one or more Lewis acid(s) is represented by the formula  $MX_4$ ; wherein M is a Group 4, 5, or 14 metal; and each X is a halogen.
31. The copolymer of claim 12, wherein the one or more Lewis acid(s) is represented by the formula  $MR_nX_{4-n}$ ; wherein M is Group 4, 5, or 14 metal; each R is a monovalent C<sub>1</sub> to C<sub>12</sub> hydrocarbon radical independently selected from the group consisting of an alkyl, aryl, arylalkyl, alkylaryl and cycloalkyl radicals; n is an integer from 0 to 4; and each X is a halogen.
32. The copolymer of claim 12, wherein the one or more Lewis acid(s) is represented by the formula  $M(RO)_nR'mX_{4-(m+n)}$ ; wherein M is Group 4, 5, or 14 metal; each RO is a monovalent C<sub>1</sub> to C<sub>30</sub> hydrocarboxy radical independently selected from the group consisting of an alkoxy, aryloxy, arylalkoxy, alkylaryloxy radicals;

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each R' is a monovalent C<sub>1</sub> to C<sub>12</sub> hydrocarbon radical independently selected from the group consisting of an alkyl, aryl, arylalkyl, alkylaryl and cycloalkyl radicals;

n is an integer from 0 to 4;

m is an integer from 0 to 4, wherein the sum of n and m is not more than 4;

and

each X is a halogen.

33. The copolymer of claim 12, wherein the one or more Lewis acid(s) is represented by the formula M(RC=OO)<sub>n</sub>R'<sub>m</sub>X<sub>4-(m+n)</sub>;

wherein M is Group 4, 5, or 14 metal;

each RC=OO is a monovalent C<sub>2</sub> to C<sub>30</sub> hydrocarbacyl radical independently selected from the group consisting of an alkacyloxy, arylacyloxy, arylalkylacyloxy, alkylarylcacyloxy radicals;

each R' is a monovalent C<sub>1</sub> to C<sub>12</sub> hydrocarbon radical independently selected from the group consisting of an alkyl, aryl, arylalkyl, alkylaryl and cycloalkyl radicals;

n is an integer from 0 to 4;

m is an integer from 0 to 4, wherein the sum of n and m is not more than 4;

and

each X is a halogen.

34. The copolymer of claim 12, wherein the one or more Lewis acid(s) is represented by the formula MOX<sub>3</sub>;

wherein M is a Group 5 metal; and

each X is a halogen.

35. The copolymer of claim 12, wherein the one or more Lewis acid(s) is represented by the formula MX<sub>3</sub>;

wherein M is a Group 13 metal; and

each X is a halogen.

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36. The copolymer of claim 12, wherein the one or more Lewis acid(s) is represented by the formula  $MR_nX_{3-n}$  :  
wherein M is a Group 13 metal;  
each R is a monovalent C<sub>1</sub> to C<sub>12</sub> hydrocarbon radical independently selected from the group consisting of an alkyl, aryl, arylalkyl, alkylaryl and cycloalkyl radicals;  
*n* is an integer from 1 to 3; and  
each X is a halogen.
37. The copolymer of claim 12, wherein the one or more Lewis acid(s) is represented by the formula  $M(RO)_nR'_mX_{3-(n+m)}$ ;  
wherein M is a Group 13 metal;  
each RO is a monovalent C<sub>1</sub> to C<sub>30</sub> hydrocarboxy radical independently selected from the group consisting of an alkoxy, aryloxy, arylalkoxy, alkylaryloxy radicals;  
each R' is a monovalent C<sub>1</sub> to C<sub>12</sub> hydrocarbon radical independently selected from the group consisting of an alkyl, aryl, arylalkyl, alkylaryl and cycloalkyl radicals;  
*n* is an integer from 0 to 3;  
*m* is an integer from 0 to 3, wherein the sum of *n* and *m* is from 1 to 3; and  
each X is a halogen.
38. The copolymer of claim 12, wherein the one or more Lewis acid(s) is represented by the formula  $M(RC=OO)_nR'_mX_{3-(n+m)}$ ;  
wherein M is a Group 13 metal;  
each RC=OO is a monovalent hydrocarbacyl radical independently selected from the group independently selected from the C<sub>2</sub> to C<sub>30</sub> group consisting of an alkacyloxy, arylacyloxy, arylalkylacyloxy, alkylarylaceyloxy radicals;  
each R' is a monovalent C<sub>1</sub> to C<sub>12</sub> hydrocarbon radical independently selected from the group consisting of an alkyl, aryl, arylalkyl, alkylaryl and cycloalkyl radicals;

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*n* is an integer from 0 to 3;

*m* is a integer from 0 to 3, wherein the sum of *n* and *m* is from 1 to 3; and each X is a halogen.

39. The copolymer of claim 12, wherein the one or more Lewis acid(s) is represented by the formula  $MX_y$ ;  
wherein M is a Group 15 metal;  
each X is a halogen; and  
*y* is 3, 4 or 5.
40. The copolymer of claim 12, wherein the one or more Lewis acid(s) is represented by the formula  $MR_nX_{y-n}$ ;  
wherein M is a Group 15 metal;  
each R is a monovalent C<sub>1</sub> to C<sub>12</sub> hydrocarbon radical independently selected from the group consisting of an alkyl, aryl, arylalkyl, alkylaryl and cycloalkyl radicals;  
*n* is an integer from 0 to 4;  
*y* is 3, 4 or 5, wherein n is less than y; and  
each X is a halogen.
41. The copolymer of claim 12, wherein the one or more Lewis acid(s) is represented by the formula  $M(RO)_nR'mX_{y-(m+n)}$ ;  
wherein M is a Group 15 metal,  
each RO is a monovalent C<sub>1</sub> to C<sub>30</sub> hydrocarboxy radical independently selected from the group consisting of an alkoxy, aryloxy, arylalkoxy, alkylaryloxy radicals;  
each R' is a monovalent C<sub>1</sub> to C<sub>12</sub> hydrocarbon radical independently selected from the group consisting of an alkyl, aryl, arylalkyl, alkylaryl and cycloalkyl radicals;  
*n* is an integer from 0 to 4;  
*m* is an integer from 0 to 4;  
*y* is 3, 4 or 5, wherein the sum of *n* and *m* is less than y; and

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each X is a halogen.

42. The copolymer of claim 12, wherein the one or more Lewis acid(s) is represented by the formula  $M(RC=OO)_nR'_mX_{y-(m+n)}$ ;  
wherein M is a Group 15 metal;  
each RC=OO is a monovalent C<sub>2</sub> to C<sub>30</sub> hydrocarbacyloxy radical independently selected from the group consisting of an alkacyloxy, arylacyloxy, arylalkylacyloxy, alkylarylacyloxy radicals;  
each R' is a monovalent C<sub>1</sub> to C<sub>12</sub> hydrocarbon radical independently selected from the group consisting of an alkyl, aryl, arylalkyl, alkylaryl and cycloalkyl radicals;  
 $n$  is an integer from 0 to 4;  
 $m$  is an integer from 0 to 4;  
 $y$  is 3, 4 or 5, wherein the sum of  $n$  and  $m$  is less than  $y$ ; and  
each X is a halogen.
43. The copolymer of claim 12, wherein the one or more Lewis acid(s) is independently selected from the group consisting of titanium tetrachloride, titanium tetrabromide, vanadium tetrachloride, tin tetrachloride, zirconium tetrachloride, titanium bromide trichloride, titanium dibromide dichloride, vanadium bromide trichloride, tin chloride trifluoride, benzyltitanium trichloride, dibenzyltitanium dichloride, benzylzirconium trichloride, dibenzylzirconium dibromide, methyltitanium trichloride, dimethyltitanium difluoride, dimethyltin dichloride, phenylvanadium trichloride, methoxytitanium trichloride, n-butoxytitanium trichloride, di(isopropoxy)titanium dichloride, phenoxytitanium tribromide, phenylmethoxyzirconium trifluoride, methyl methoxytitanium dichloride, methyl methoxytin dichloride, benzyl isopropoxyvanadium dichloride, acetoxytitanium trichloride, benzoylzirconium tribromide, benzoyloxytitanium trifluoride, isopropoxytin trichloride, methyl acetoxytitanium dichloride, benzyl benzoyloxyvanadium chloride, vanadium oxytrichloride, aluminum trichloride, boron trifluoride, gallium

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trichloride, indium trifluoride, ethylaluminum dichloride, methylaluminum dichloride, benzylaluminum dichloride, isobutylgallium dichloride, diethylaluminum chloride, dimethylaluminum chloride, ethylaluminum sesquichloride, methylaluminum sesquichloride, trimethylaluminum, triethylaluminum, methoxyaluminum dichloride, ethoxyaluminum dichloride, 2,6-di-tert-butylphenoxyaluminum dichloride, methoxy methylaluminum chloride, 2,6-di-tert-butylphenoxy methylaluminum chloride, isopropoxygallium dichloride, phenoxy methylindium fluoride, acetoxyaluminum dichloride, benzyloxyaluminum dibromide, benzyloxygallium difluoride, methyl acetoxyaluminum chloride, isopropoxyindium trichloride, antimony hexachloride, antimony hexafluoride, arsenic pentafluoride, antimony chloride pentafluoride, arsenic trifluoride, bismuth trichloride arsenic fluoride tetrachloride, tetraphenylantimony chloride, triphenylantimony dichloride, tetrachloromethoxyantimony, dimethoxytrichloroantimony, dichloromethoxyarsine, chlorodimethoxyarsine, difluoromethoxyarsine, acetatotetrachloroantimony, (benzoato) tetrachloroantimony, and bismuth acetate chloride.

44. The copolymer of claim 12, wherein the one or more Lewis acid(s) is independently selected from the group consisting of aluminum trichloride, aluminum tribromide, ethylaluminum dichloride, ethylaluminum sesquichloride, diethylaluminum chloride, methylaluminum dichloride, methylaluminum sesquichloride, dimethylaluminum chloride, boron trifluoride, and titanium tetrachloride.
45. The copolymer of claim 12, wherein the Lewis acid is not a compound represented by formula  $MX_3$ , where M is a group 13 metal, X is a halogen.
46. The copolymer of claim 12, wherein the one or more initiator(s) comprise a hydrogen halide, a carboxylic acid, a carboxylic acid halide, a sulfonic acid, an alcohol, a phenol, a polymeric halide, a tertiary alkyl halide, a

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tertiary aralkyl halide, a tertiary alkyl ester, a tertiary aralkyl ester, a tertiary alkyl ether, a tertiary aralkyl ether, an alkyl halide, an aryl halide, an alkylaryl halide or an arylalkylacid halide.

47. The copolymer of claim 12, wherein the one or more initiator(s) is independently selected from the group consisting of HCl, H<sub>2</sub>O, methanol, (CH<sub>3</sub>)<sub>3</sub>CCl, C<sub>6</sub>H<sub>5</sub>C(CH<sub>3</sub>)<sub>2</sub>Cl, (2-Chloro-2,4,4-trimethylpentane) and 2-chloro-2-methylpropane.
48. The copolymer of claim 12, wherein the one or more initiator(s) is independently selected from the group consisting of hydrogen chloride, hydrogen bromide, hydrogen iodide, acetic acid, propanoic acid, butanoic acid; cinnamic acid, benzoic acid, 1-chloroacetic acid, dichloroacetic acid, trichloroacetic acid, trifluoroacetic acid, p-chlorobenzoic acid, p-fluorobenzoic acid, acetyl chloride, acetyl bromide, cinnamyl chloride, benzoyl chloride, benzoyl bromide, trichloroacetylchloride, trifluoroacetylchloride, p-fluorobenzoylchloride, methanesulfonic acid, p-trifluoromethanesulfonic acid, trichloromethanesulfonic acid, p-toluenesulfonic acid, methanesulfonyl chloride, methanesulfonyl bromide, trichloromethanesulfonyl chloride, trifluoromethanesulfonyl chloride, p-toluenesulfonyl chloride, methanol, ethanol, propanol, 2-propanol, 2-methylpropan-2-ol, cyclohexanol, benzyl alcohol, phenol, 2-methylphenol, 2,6-dimethylphenol, p-chlorophenol, p-fluorophenol, 2,3,4,5,6-pentafluorophenol, and 2-hydroxynaphthalene.
49. The copolymer of claim 12, wherein the one or more initiator(s) is independently selected from the group consisting of 2-chloro-2,4,4-trimethylpentane; 2-bromo-2,4,4-trimethylpentane; 2-chloro-2-methylpropane; 2-bromo-2-methylpropane; 2-chloro-2,4,4,6,6-pentamethylheptane; 1-chloro-1-pentamethylheptane; 2-bromo-2,4,4,6,6-pentamethylheptane; 1-chloro-1-methylethylbenzene; 1-chloroadamantane; 1-chloroethylbenzene; 1, 4-bis(1-chloro-1-methylethyl) benzene; 5-tert-butyl-1,3-bis(1-chloro-1-

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methylethyl) benzene; 2-acetoxy-2,4,4-trimethylpentane; 2-benzoyloxy-methylethyl) benzene; 2-acetoxy-2-methylpropane; 2-benzoyloxy-2-methylpropane; 2-acetoxy-2,4,4,6,6-pentamethylheptane; 2-benzoyl-2,4,4,6,6-pentamethylheptane; 1-acetoxy-1-methylethylbenzene; 1-acetoxyadamantane; 1-benzoyloxyethylbenzene; 1,4-bis(1-acetoxy-1-methylethyl) benzene; 5-tert-butyl-1,3-bis(1-acetoxy-1-methylethyl) benzene; 2-methoxy-2,4,4-trimethylpentane; 2-isopropoxy-2,4,4-trimethylpentane; 2-methoxy-2-methylpropane; 2-benzylbenzylbenzene; 2-methoxy-2,4,4,6,6-pentamethylheptane; 2-isopropoxy-methylethyl) benzene; 1-methoxy-1-methylethylbenzene; 1-methoxyadamantane; 1-methoxyethylbenzene; 1,4-bis(1-methoxy-1-methylethyl) benzene; 5-tert-butyl-1,3-bis(1-methoxy-1-methylethyl) benzene, and 1,3,5-tris(1-chloro-1-methylethyl) benzene.

50. The copolymer of claim 12, wherein the one or more initiator(s) further comprise a weakly-coordinating anion.
51. The copolymer of claim 12, wherein the one or more initiator(s) comprise greater than 30 ppm water (based upon weight).
52. The copolymer of claim 12, wherein the contacting further comprises contacting one or more monomer(s) independently selected from the group consisting of olefins, alpha-olefins, disubstituted olefins, isoolefins, conjugated dienes, non-conjugated dienes, styrenics, substituted styrenics, and vinyl ethers.
53. The copolymer of claim 12, wherein the contacting further comprises contacting one or more monomer(s) independently selected from the group consisting of styrene, para-alkylstyrene, para-methylstyrene, alpha-methylstyrene, divinylbenzene, diisopropenylbenzene, isobutylene, 2-methyl-1-butene, 3-methyl-1-butene, 2-methyl-2-pentene, isoprene, butadiene, 2,3-dimethyl-1,3-butadiene,  $\beta$ -pinene, myrcene, 6,6-dimethyl-fulvene,

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hexadiene, cyclopentadiene, methyl cyclopentadiene, piperylene, methyl vinyl ether, ethyl vinyl ether, and isobutyl vinyl ether.

54. The copolymer of any of the preceding claims, wherein the copolymer is halogenated to form a halogenated copolymer.
55. The copolymer of claim 54, wherein the halogenated copolymer is halogenated with chlorine or bromine.
56. The copolymer of claim 54, wherein the halogen content is greater than 0.5 wt% based upon the weight of the halogenated copolymer.
57. The copolymer of claim 54, wherein the halogen content is from 0.5 wt% to 3.0 wt% based upon the weight of the halogenated copolymer.
58. The copolymer of any of the preceding claims, wherein the copolymer has a Mw of from greater than 50,000.
59. The copolymer of any of the preceding claims, wherein the copolymer has a Mw of from greater than 100,000.
60. The copolymer of any of the preceding claims, wherein the copolymer has a Mw of from greater than 500,000.
61. The copolymer of any of the preceding claims, wherein the copolymer has a Mw of from greater than 1,000,000.
62. The copolymer of any of the preceding claims, wherein the copolymer has a MWD of from greater than 2.
63. The copolymer of any of the preceding claims, wherein the copolymer has a MWD of from 2 to 6.

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64. The copolymer of any of the preceding claims, wherein the copolymer has a Mooney viscosity of at least  $20 \pm 5$  (ML 1 + 8 at  $125^{\circ}\text{C}$ , ASTM D 1646).
65. The copolymer of any of the preceding claims, wherein the copolymer has a Mooney viscosity of from  $20 \pm 5$  to  $60 \pm 5$  (ML 1 + 8 at  $125^{\circ}\text{C}$ , ASTM D 1646).
66. The copolymer of any of the preceding claims, wherein the copolymer has a  $\text{g}'_{\text{vis,avg}}$  from greater than or equal to 0.980 as determined by triple detection SEC.
67. The copolymer of any of the preceding claims, wherein the copolymer has a  $\text{g}'_{\text{vis,avg}}$  from greater than or equal to 0.990 as determined by triple detection SEC.
68. The copolymer of any of the preceding claims, wherein the copolymer has a  $\text{g}'_{\text{vis,avg}}$  from greater than or equal to 0.995 as determined by triple detection SEC.
69. The copolymer of any of the preceding claims, wherein the copolymer has no long chain branching.
70. A blend comprising the copolymer of any of the preceding claims and a secondary rubber independently from the group consisting of at least one of natural rubber, polyisoprene rubber, poly(styrene-co-butadiene) rubber (SBR), polybutadiene rubber (BR), poly(isoprene-co-butadiene) rubber (IBR), styrene-isoprene-butadiene rubber (SIBR), ethylene-propylene rubber (EPR), ethylene-propylene-diene rubber (EPDM), polysulfide, isobutylene/cyclopentadiene copolymer rubber, isobutylene/methyl cyclopentadiene copolymer rubber, nitrile rubber, propylene oxide polymers, star-branched butyl rubber and halogenated star-branched butyl

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rubber, brominated butyl rubber, chlorinated butyl rubber, star-branched polyisobutylene rubber, star-branched brominated butyl (polyisobutylene/isoprene copolymer) rubber; poly(isobutylene-co-p-methylstyrene) and halogenated poly(isobutylene-co-p-methylstyrene), halogenated poly(isobutylene-co-isoprene-co-p-methylstyrene), poly(isobutylene-co-isoprene-co-styrene), halogenated poly(isobutylene-co-isoprene-co-styrene), halogenated poly(isobutylene-co-isoprene-co-a-methylstyrene) and mixtures thereof.